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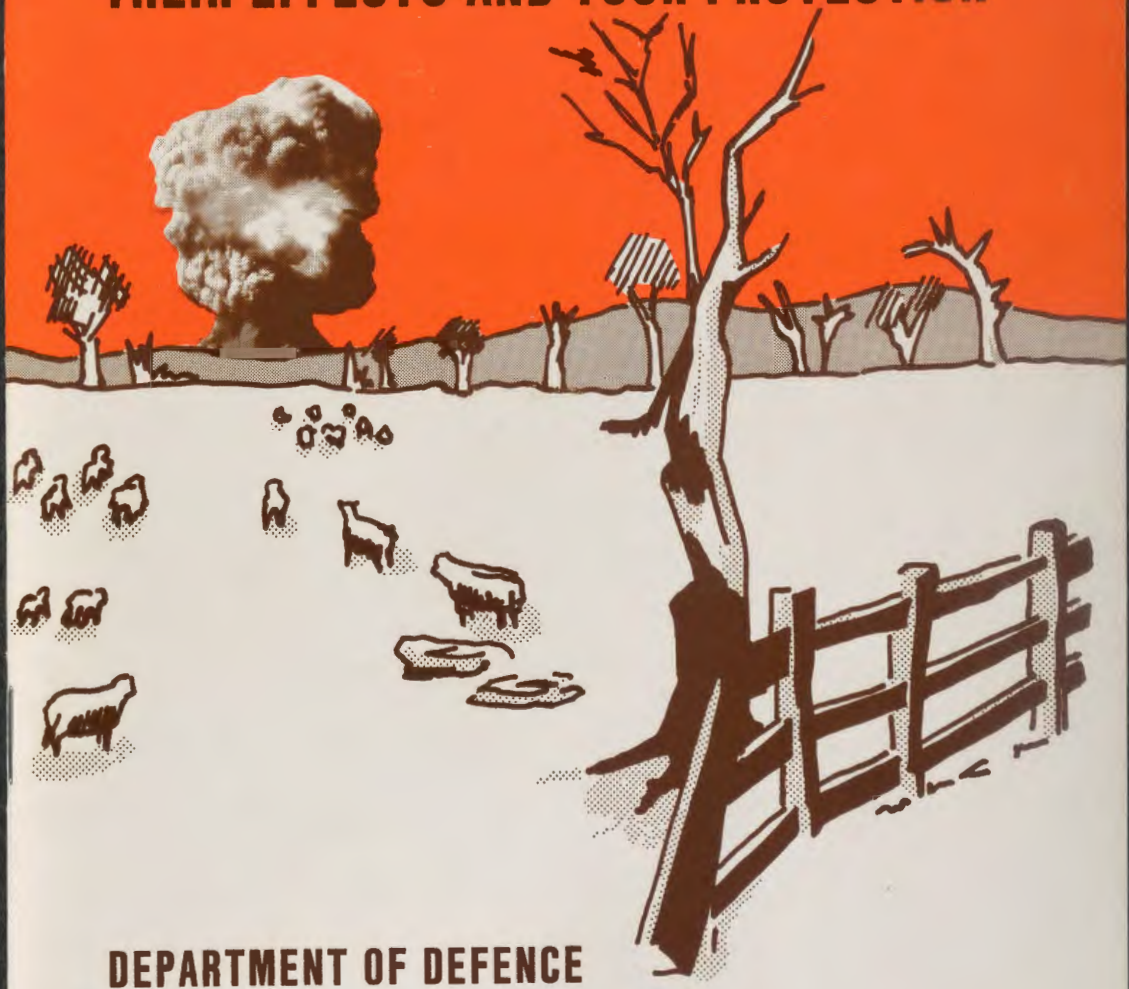
NUCLEAR WEAPONS

THEIR EFFECTS AND YOUR PROTECTION



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NUCLEAR WEAPONS - THEIR EFFECTS AND YOUR PROTECTION

1. In recent years a great deal of public attention has been focussed on the subject of nuclear weapons. Much of the information available has been prepared for people in the Northern Hemisphere. Australia's position, distant from the centres of the world power, is quite different.

2. The aim of this booklet is therefore to provide information relevant to Australians on the risks, and protective measures to meet them, if nuclear war were to occur despite all the efforts to maintain peace and security to which the Australian Government is contributing.

3. Australia's security, like that of all nations, ultimately depends on preserving stability in the superpower relationship and avoiding war between them, above all nuclear war. The continuing expansion and refinement of nuclear arsenals pose a challenge to the maintenance of stable deterrence. Thus, the Government attaches importance to the achievement in both the nuclear and conventional fields of verifiable arms control agreements that provide for more stable deterrence at all possible levels of armament, particularly nuclear armament. We are active in international disarmament negotiations, and have proposed several important measures by which the risk of nuclear war will be further reduced. These include such things as universal adherence to the Nuclear Non-Proliferation Treaty, a seismic monitoring network, a South Pacific Nuclear Free Zone and other arms control measures. By such means we would look for reductions in the number of weapons the nuclear powers now have and prevention of their acquisition by countries which do not now possess them. Through these efforts we hope to achieve a more solid basis for international stability and peace. We recognise that progress in achieving agreements is slow. In the interim the Government considers it important to maintain a stable strategic balance to support mutual deterrence and as a basis for substantive arms control and disarmament negotiations.

4. The joint Australia/United States defence facilities at North-West Cape, Pine Gap and Nurrungar each have an important role in helping to maintain stability in the strategic relationship between the superpowers and in helping to deter war. While Australia might appear remote from the areas of the globe where any nuclear war would be fought, it would inevitably be profoundly affected by such a conflict. United States strategy is to deter war. Australia supports the concept of deterrence.

5. The benefits and costs for Australia in co-operating with the United States in the joint facilities have been carefully evaluated by the Government. They serve Australian and US interests. They are jointly managed and operated by the Australian and United States Governments and their operation is governed by a set of principles designed to protect Australian sovereignty and interests. All their functions and activities require, and have, the full knowledge and concurrence of the Australian government. Australian personnel are fully involved

in all aspects of the operations of the joint facilities. Were Australia to cease such co-operation there would only be adverse consequences for international security and higher risk of global war. This would neither serve Australia's interests nor those of the international community generally. The presence in Australia of these facilities carries with it the risk that, in the event of superpower conflict, these facilities might be attacked. However the risk that such conflict might occur, deliberately or as a result of some accident, is very low and the functions carried out be the joint facilities help to ensure that this remains the case.

6. We have accepted that we cannot entirely preclude the possibility of nuclear attack on the joint facilities. All major centres of population are around the national coastline and are a considerable distance from any of the facilities and it is unlikely that attack on any of these would constitute a serious threat to major cities. Nevertheless, people living near the facilities would be at risk. Federal, State and Territory Governments recognise this fact and are working in concert to address the special problems confronting those communities at risk.

7. Clearly if a nuclear attack were mounted on an urban or industrial area it would result in mass casualties of catastrophic proportions. Whatever the scenario, the carnage would be enormous, and health and medical services would be unable to cope with the number of dead and injured. While medical resources would be intact in the rural or non-urban situation, it could not be expected that assistance could be mobilised to help with triage, evacuation and appropriate medical care to any significant extent in devastated urban areas.

8. However, although we host the joint facilities, nuclear weapons are not allowed on Australian soil. Consequently, unlike Northern Hemisphere countries, we do not present the kind of potential military threat which would provide a rationale for nuclear attacks against Australian forces or its centres of industry and population. These considerations provide some very good grounds for judging that none of the major Australian centres of population should suffer from nuclear attack in the remote event of a nuclear war.

9. Consequently the Commonwealth Government does not consider the remote threat to Australian communities, other than those adjacent to the joint facilities, justifies special actions. It does however recognise that many citizens have a fundamental concern regarding the nuclear threat and may wish to make individual preparations.

10. Against all the effects described in the subsequent chapters there are practical measures to avoid or minimize injury or death. Some measures, such as dispersal, can be taken in a period when the risk of global nuclear war is clear; others would be taken immediately before or after attack.

11. For nations to risk destruction, which would be inevitable in a prolonged nuclear war, they would need to

consider their fundamental national interests threatened. Those concerns and attempts to safeguard them, short of major war, would be evident and provide warning of the possibility of war. In such circumstances the aim should be to make best use of the warning time available either to disperse, or alternatively to prepare shelters if that were more appropriate.

12. This booklet is part of the process of informing people in advance of the types of measures that can be taken. It is in seven parts:

PART 1 - General Information on Nuclear Weapons

PART 2 - Types and Heights of Nuclear Weapons

PART 3 - The Effects of Nuclear Weapons Explosions

PART 4 - Radiation Effects on Humans

PART 5 - Protective Measures against the Effects of Nuclear Weapons Explosions

PART 6 - Shelter Survival Kit

PART 7 - Food Supplies after a Nuclear Explosion

PART 1

GENERAL INFORMATION ON NUCLEAR WEAPONS

1.1 Conventional high explosive weapons contain substances which, on detonation, release energy as a result of chemical changes. The atoms of carbon, hydrogen, oxygen and nitrogen in the weapons are released and recombine to form the waste products of the explosion.

1.2 Nuclear explosives, weight for weight, liberate vastly greater amounts of energy than conventional explosives and this energy comes from the inner core or nucleus of each atom. In nuclear explosions, measurable quantities of matter are converted into energy, but only a few of the known elements have atoms capable of releasing large quantities of nuclear energy.

1.3 Some knowledge of the structure of atoms helps towards an understanding of nuclear weapons and their effects; moreover, it is difficult to describe some aspects of these weapons without using scientific terms like isotopes, neutrons, and electrons. Appendix 1 contains brief notes on the structure of matter, fission reactions, critical sizes of fissile materials, and thermonuclear fusion reactions.

Fission (or Atomic) Weapons

1.4 The large atoms of the heavy metals, plutonium (made artificially in a nuclear reactor) and uranium, can split into two not quite equal parts, a process which is called FISSION. This is the process which takes place in the explosion of atomic weapons and the products resulting from such a process are known as fission products.

Fusion (or Hydrogen) Weapons

1.5 Another process by which nuclear energy can be released is called FUSION, because certain kinds of hydrogen atoms (eg deuterium and tritium) can fuse together at temperatures of millions of degrees celsius. The temperatures attained in the explosion of atomic fission weapons are nearly as high as those at the centre of the sun. Fusion or hydrogen weapons therefore need a small atomic or fission charge as a trigger and for this reason they are sometimes known as fission-fusion devices and are termed THERMONUCLEAR weapons.

1.6 For equal weights of nuclear explosive charge, the fusion or H-bomb releases about two-and-a-half times as much energy as the fission or atomic bomb. Another important difference is that the size of a purely fission-type bomb is limited because, above a certain critical size, a lump of fissile material is self-disruptive. A fusion or hydrogen bomb, on the other hand, has no such limit to its size other than that imposed by the method of delivery on to the target. It is possible also

to have a fission-fusion-fission type of thermonuclear weapon in which a fusion or hydrogen bomb, containing a core of fissile uranium-235 (U-235) as a trigger, is encased in uranium-238 (U-238). This U-238 casing also undergoes fission from the high speed neutrons produced in the hydrogen fusion explosion and, since the casing might be many times heavier than the fissile core of U-235, larger quantities of fission products would be released as fallout from such a weapon.

Energy Distribution in a Nuclear Explosion

1.7 The large quantities of nuclear energy released in an explosion on or near ground level are distributed approximately in the following way:

45 per cent in the form of blast and shock waves
35 per cent as light and heat radiation
5 per cent as initial nuclear radiations
15 per cent as residual radiation from fission products

Weapon Yield (or Power)

1.8 The yield of a nuclear weapon is the total amount of energy released on explosion, including all the forms of energy mentioned above. It is expressed in terms of the number of tonnes of TNT which would release the same total energy on detonation. The yield of a weapon is also referred to as the power of a weapon.

The Fireball and the Cloud

1.9 The contents of a nuclear weapon are vaporised in the luminous fireball which rapidly expands and cools, with subsequent formation of the familiar radioactive mushroom cloud and stem. The fireball on expansion becomes lighter than the surrounding atmosphere and starts to shoot upwards at speeds which may reach almost 500 kilometres per hour. Its maximum size, its duration as a luminous fireball, the speed at which it will rise and the height to which the cloud will ascend, depend upon weapon yield, and, to some extent, upon the height of burst and prevailing meteorological conditions.

1.10 Air temperature in temperate latitudes falls gradually with increasing altitude and, at a height of about 12,000 to 13,000 metres, there is a region called the tropopause where it remains constant at about -60 degrees celsius. Above this is the stratosphere. The cloud produced by the explosion of a 20 kt * weapon would not penetrate the tropopause if exploded near ground level but would flatten out into the well-known mushroom shape. The clouds from Mt weapons, on the other hand, would penetrate the tropopause and rise to heights of 30,000 metres or more, into the stratosphere, depending upon the weapon yield.

* Kilotonne abbreviated to kt; megatonne abbreviated to Mt. A one kt weapon is equal to one thousand tonnes of high explosives, whereas a one Mt weapon is equal to one million tonnes of high explosives.

Possible Methods of Attack with Nuclear Weapons

1.11 Weapon design has improved so much that it is possible to incorporate kt or Mt warheads in a variety of weapons, including ballistic missiles with a range of several thousand kilometres. Some possible means of delivery are:

a. manned bombers which may be supersonic;

b. pilotless vehicles released from land or from ships - SSMs (Surface to Surface Missiles *);

c. guided bombs released from aircraft several hundred kilometres from the target - ASMs (Air to Surface Missiles *);

d. ballistic missiles - IRBMs (Intermediate Range Ballistic Missiles) and ICBMs (Inter-Continental Ballistic Missiles) released from land, ships off-shore, submerged submarines; and

e. saboteurs.

* Including the so-called cruise missiles.

1.12 Winged missiles can be guided to the target. However, since they depend on air to feed the engine, to support the wing loading and to exert forces on control surfaces, they are limited in speed and height of operation and are therefore more vulnerable to counter attack than ballistic missiles. The latter can be guided into the correct direction and altitude to reach the target as long as the rocket motor is operating; thereafter they must follow a ballistic path like a shell from a gun. However, since long-range ballistic missiles travel for most of their range at altitudes of several hundred kilometres where there is practically no air resistance and can reach maximum speeds of 25,000 kilometres per hour, they reach their targets in a matter of minutes.

1.13 To counter attacks from IRBMs and ICBMs within the time available between launching and impact, it is necessary to detect the weapon, to compute its ballistic path, and to destroy it with a defensive missile as far away as possible from its intended target.

The Neutron Weapon

1.14 The neutron weapon (more correctly called the 'enhanced radiation weapon') has been designed specifically as a weapon for use on the actual field of battle, purportedly to destroy the occupants of vehicles such as tank crews and massed troop formations, whilst causing minimal damage to nearby built-up areas containing non-combatants. The dangerous effects of these weapons are not expected to extend beyond the battle area.

1.15 Fallout would be virtually eliminated because the weapon would be air-burst. As its name implies, the neutron weapon releases high energy neutrons which are able to penetrate dense materials such as tank armour. Because the neutrons do not travel far, the danger is restricted to the persons on the battlefield. Such weapons are necessarily of small yield (1-2 kt).

1.16 One area in which they could be used effectively would be in the European 'theatre', for example, if NATO countries were besieged by massed tank formations from hostile countries. Their use in an attack on Australia is considered to be very unlikely.

Factors Affecting the Results of a Nuclear Attack

1.17 The damage to life and property caused by nuclear weapons explosions depends on:

a. the number and power of the bombs;

b. the type of burst (air, water or ground) of each bomb and its location in regard to urban areas;

c. the prevailing weather conditions, particularly wind strengths and directions at levels through which radioactive particles might fall;

d. the method of attack and the time available to give actual public warning of attack; and

e. the measures for self-protection taken before and maintained after the attack.

PART 2

TYPES AND HEIGHTS OF NUCLEAR EXPLOSIONS

2.1 The effects produced by the explosion of a nuclear weapon can vary considerably according to the height at which it is burst. Nuclear weapons may be fused to burst:

a. on or near the ground (called ground bursts because a large part of the fireball touches the ground);

b. in shallow water in a harbour, lake or river, or in deep water at sea (called water bursts);

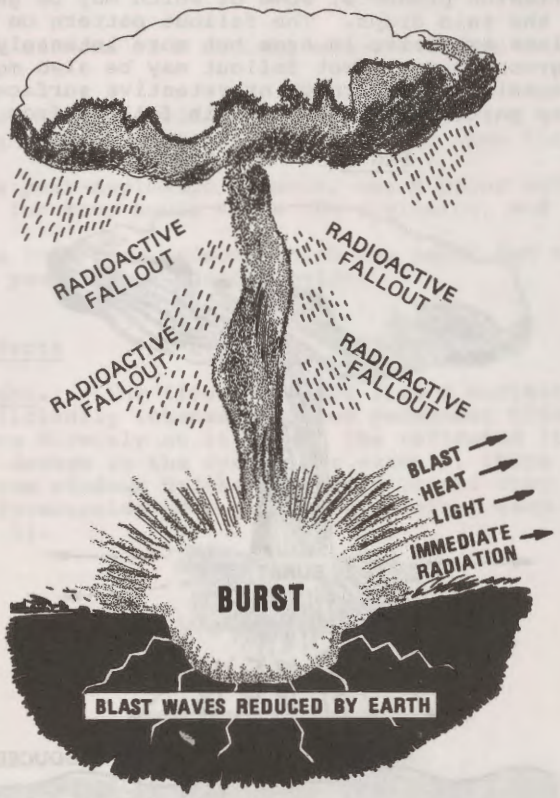
c. high in the air (called air bursts because the fireball does not touch the ground, or only a small part touches the ground); or

d. very high, on the fringe of the Earth's atmosphere.

2.2 Both ground and air bursts produce dangerous effects immediately. These are the intense light (or flash), heat, radiation and blast, as well as the creation of an electromagnetic pulse (or wave), called EMP, which could cause considerable problems with computers and with electrical and communications systems.

2.3 Ground Bursts. Ground bursts produce an additional, but delayed danger in the form of radioactive fallout (FIG. 1), incorrectly referred to as 'residual radiation'. This results from fission products being attached to ground materials which had been previously sucked into the fireball and which fall back to earth. With a ground burst, an appreciable amount of the total energy released is dissipated in forming a crater and some of the initial heat and nuclear radiations will be absorbed by the material displaced and lifted from the crater. Consequently, the range of blast damage, fire and skin burns and the effects from initial nuclear radiation will be less than they would be for an air burst of the same yield.

FIG 1. GROUND BURST

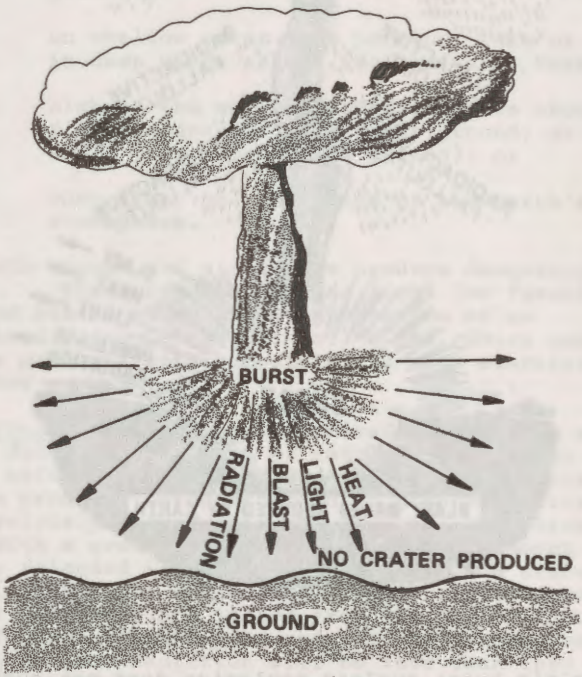


2.4 An air burst nuclear explosion does not suck up ground material into the fireball. Therefore radioactive fallout would not be an effect of this explosion (Fig. 2), although if heavy rainfall were present, some of the fission products from the lower part of the explosion's cloud could be carried to earth before the cloud disperses. The nuclear explosions over Hiroshima and Nagasaki in Japan were air bursts from 12.5 kt and 22 kt yields respectively. The physical devastation of the cities was caused by heat and blast. Immediate gamma radiation was also produced by the two explosions, which although potentially very dangerous to life if received in sufficient quantities, caused only a fraction of the total deaths compared to heat and blast.

2.5 The height and the yield of an air burst determine the extent of blast damage at the surface and this in turn depends upon the type of terrain. With water bursts, large quantities

of water and, in shallow water, bottom mud will be carried up into the fireball. When the vaporised water in the cloud reaches a high altitude it could condense to rain and bring down with it radioactive fission products, some of which may be gelatinous or dissolved in the rain drops. The fallout pattern on neighbouring land may be less extensive in area but more intensely radioactive than from a ground burst. Wet fallout may be also more difficult to remove, especially from rough or retentive surfaces, than the relatively dry particles which occur in fallout from a ground burst.

FIG 2. AIR BURST



2.6 A nuclear weapon may burst in deep water and, apart from absence of mud, the effects will be similar to those from a surface burst except that a larger amount of the total energy released will be expended in vaporising water, in producing a shock wave through the water and in forming surface waves. Most of the fission products should be trapped in the water near the burst and will diffuse and disperse rapidly.

2.7 There are in existence today nuclear weapons many times more powerful than kt-range ie. up to 2Ø Mt. There have been trials with weapons of higher yield than this, but there would be few targets in the world to justify the use of such powerful weapons. It is important however, to note that their effects do not increase in direct ratio to increases in yield.

PART 3

THE EFFECTS OF NUCLEAR WEAPONS EXPLOSIONS

3.1 The effects of a nuclear weapons explosion can be divided into:

a. the immediate effects at the time of the explosion ie, light, heat, initial radiation and then blast effects;

b. the post-explosion effects, which occur within minutes or for many hours after the explosion; and

c. the long-term effects which may occur for many months or years after the explosion.

Immediate Effects

3.2 Light. The flash of light from a nuclear explosion could be sufficiently intense to cause permanent blindness to anyone looking directly at it. Even the reflected light could cause severe damage to the eyes. For example, there could be reflection from windows before the blast breaks them. Therefore if you have forewarning of a pending explosion, keep your eyes covered (Fig 3).

FIG 3

AVOID LOOKING AT THE FLASH

3.3 Heat. With the explosion of a 20 kt ground burst weapon, heat (or thermal) radiation travelling at the speed of light starts immediately and lasts for no longer than 2 seconds. Most of it will occur in the first 1/2 second. With a 10 Mt explosion heat lasts for about 30 seconds, with the most intense occurring in the first 10 seconds. The effects on exposed people could be reddening, blistering or charring of the skin depending on how close a person is to the explosion and on the degree of physical shielding between the explosion and the person. Following the explosion of a 20 kt weapon, heat burns would

generally affect exposed people within 3 kilometres of ground zero in the absence of any shielding, whereas a 10 Mt ground burst can radiate sufficient heat to cause heat burns as far distant as 30 kilometres from ground zero. The term "ground zero" refers to the point on the Earth's surface immediately below (or above) the point of the detonation.

3.4 The intensity of direct heat radiation received at any place may be enhanced (in a way similar to that of visible light) by reflection and scatter from clouds or from dust particles in the atmosphere, or it may be reduced by passing through thick fog or heavy atmospheric pollution.

3.5 Gamma Radiation. The gamma rays emitted from the explosion's fireball travel with the speed of light, having a maximum intensity period similar to heat rays, but continue for a longer period (about one minute). Gamma rays (similar to X-rays but of higher energy) are very penetrating, passing with ease through the human body and lightweight materials such as clothing. Heavy materials such as earth, bricks and concrete are less easily penetrated and, depending on composition and thickness, have the effect of absorbing gamma rays.

3.6 Neutrons. Neutrons (electrically uncharged nuclear particles) are also emitted immediately from the fireball, but their range is much smaller than the gamma rays and their effect does not significantly add to the nuclear radiation danger.

3.7 Blast. Blast is the intense pressure wave (shock-wave) travelling outwards in all directions, caused by rapid expansion of the fireball. The pressure wave travels initially at several times the speed of sound but quickly slows down to about that speed. This shock-front of highly compressed air, moving rapidly, causes severe damage to buildings and other standing objects. The blast is no different from that originating from a 'conventional' explosion except for its greater intensity.

3.8 The outwards pressure phase of blast is followed by the suction phase, resulting from air rushing back towards the explosion point. In the case of a ground burst, this backward movement of air could cause further damage by fanning existing fires generated by the heat waves.

3.9 It should be borne in mind that the range of blast damage is substantially greater from an air burst than from a ground burst weapon - as much as 30% greater from air bursts using similar sized weapons, at optimum height for maximum area of damage.

3.10 In a built-up area, blast from a 20 kt ground burst explosion will cause almost total damage to a distance of about one kilometre, the area of severe damage being within 2 1/2 kilometres from ground zero. Beyond 2 1/2 kilometres blast effects will be minor (FIG 4). A 10 Mt explosion will cause

almost total damage to a distance of about 8 kilometres from ground zero, the area of severe damage being within about 20 kilometres. The degree of damage will of course be dependent on the structure and type of buildings in the affected region.

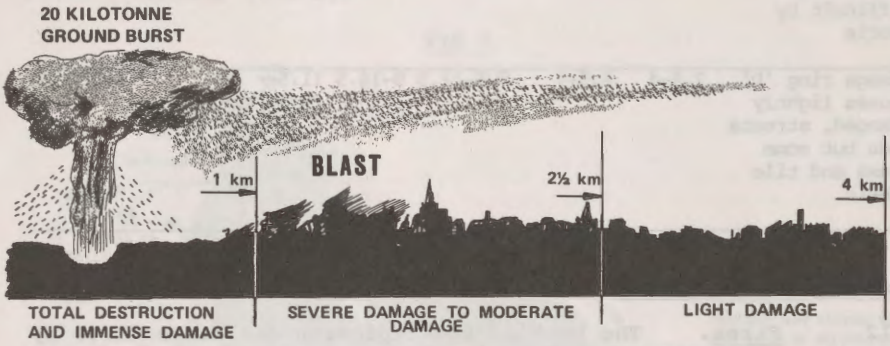


FIG 4

3.11 Table 1 summarises the ranges of various categories of damage and street blockage for ground burst weapons of different yields. This table shows that a weapon 1000 times more powerful than those that devastated Hiroshima or Nagasaki would increase the distance over which destruction occurs about tenfold, as the process of increasing weapon size is subject to the law of diminishing returns. However, the extent of damage would of course depend on the existence of natural or man-made shielding: hills, ridges, large concrete buildings. These would inhibit the outward movements of heat and blast waves.

Table 1: Average ranges of blast damage to typical houses and blockage of streets. Ground burst nuclear weapons: ranges in kilometres

Weapon power	20 kt	100 kt	1/2 Mt	1 Mt	2 Mt	5 Mt	10Mt	20 Mt
Damage ring 'A' Houses totally destroyed, streets impassable	0-1	0-1.5	0-2	0-2.5	0-3.5	0-4.5	0-6	0-7.5
Damage ring 'B' Houses irreparably damaged, streets blocked until cleared with mechanical aids	1-1.5	1.5-2	2-3	2.5-3.5	3.5-5	4.5-6.5	6-8	7.5-10

Damage ring 'C' Houses severely to moderately damaged: progress in streets made difficult by debris	1.5–2.5	2–4.5	3–7.5	3.5–9	5–11.5	6.5–16	8–19.5	10–25
Damage ring 'D' Houses lightly damaged, streets open but some glass and tile debris	2.5–4	4.5–7	7.5–11.5	9–14.5	11.5–19.5	16–25.5	19.5–32	25–40

Post-Explosion Effects

3.12 Fires. The heat of the explosion can cause fires by igniting combustible materials in the open and in buildings through windows or other openings up to 2 kilometres from a 20 kt explosion and up to 20 kilometres from a 10 Mt explosion. Heat radiation, like visible light, is reflected by light colours and absorbed by dark ones so that dark coloured objects of otherwise comparable inflammability are more likely to catch fire than white or light coloured ones.

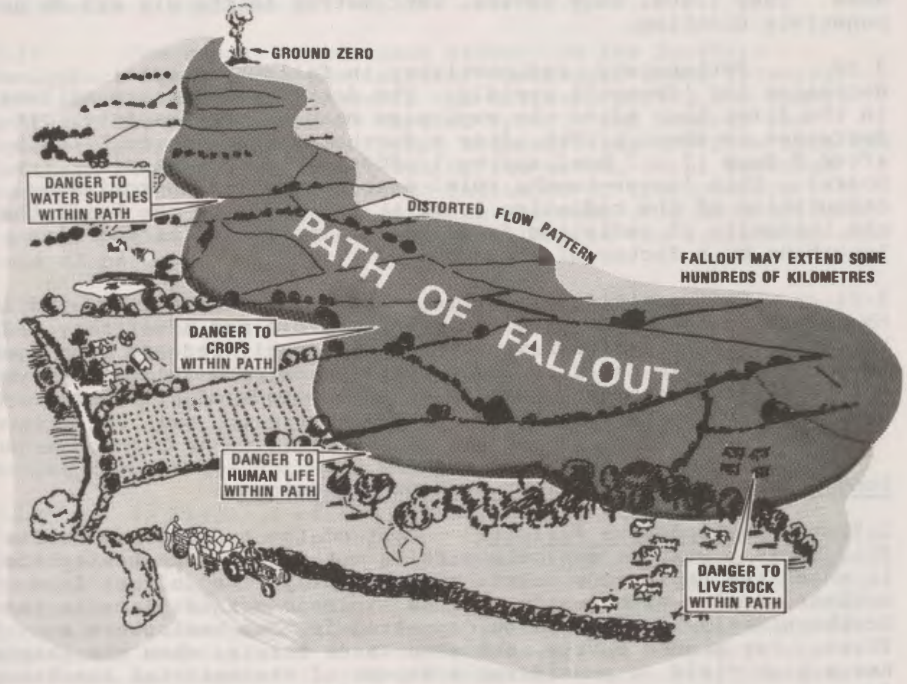
3.13 Fire Storms. Fire storms could occur only where the concentration of combustible structures is very high eg, inner-city areas close to ground zero. Given the building construction methods and materials used in Australian cities, their likelihood is very low. People sheltering in closed basements of inner-city buildings should have sufficient air to survive the duration of fires.

3.14 Radioactive Fallout. When a nuclear weapon explodes on or close to the ground, it blasts a huge crater and thousands of tonnes of pulverised soil, rock and debris are sucked up into the fireball, kilometres above the earth. These tiny airborne particles are contaminated by radioactive atoms produced by the nuclear explosion. Upon falling back to earth the particles are called 'fallout'. Similarly, nuclear explosions under, or close to the sea, draw huge amounts of water into the atmosphere and the radioactive products may attach themselves to the water.

3.15 As the fireball cools, the radioactive particles are released into the upper atmosphere. The heavier particles, which may be similar in size to sand grains, or larger, quickly fall back to earth by gravity. The lighter particles are carried by the wind, often to great distances before returning to earth. Much of the heavier fallout will begin returning to earth at or near ground zero about 30 minutes after the explosion. If the wind is blowing in the same direction at all heights, most of the the lighter particles will fall to earth over a period up to 24

hours in a plume-shaped pattern extending from ground zero to distances of hundreds of kilometres if winds are strong. Because winds are not always blowing in the same direction at all heights, the 'flow' of fallout deposits may be distorted, so that some areas of ground away from the main flow pattern could also receive fallout (FIG 5).

FIG 5


GROUND ZERO
DANGER TO WATER SUPPLIES WITHIN PATH
DISTORTED FLOW PATTERN
FALLOUT MAY EXTEND SOME HUNDREDS OF KILOMETRES
PATH OF FALLOUT
DANGER TO CROPS WITHIN PATH
DANGER TO HUMAN LIFE WITHIN PATH
DANGER TO LIVESTOCK WITHIN PATH

3.16 The heavier fallout might be seen on clean flat surfaces, but not on cultivated ground. It may not be distinguishable from other dirt on roofs or roads. The lighter fallout would not be seen and instruments would be needed to detect it or to distinguish it from ordinary dust.

3.17 Radiation from fallout is in the form of 'gamma', 'beta' and 'alpha' rays. Of these, the gamma radiation is the most penetrating and protective measures against fallout must therefore take account of gamma rays.

3.18 Beta rays travel only a few metres in air and clothing protects against them. They are less dangerous, therefore, than gamma rays. Protracted exposure to beta rays could result in burns to the skin and damage to tissues, and if fallout particles were incorporated in food or water, beta radiation could

contribute to the overall amount of radiation (or 'dose') received by internal body organs, through ingestion or inhalation.

3.19 Alpha rays have even less penetrating capability than beta rays, but if radioactive fallout particles were incorporated in food or water, or were attached to dust particles and inhaled, they (alpha rays) would also contribute to the overall radiation dose. They travel only several centimetres in the air and do not penetrate clothing.

3.20 Fortunately, radioactivity in fallout material decreases (or 'decays') rapidly. The dose rate near ground level in the first hour after the explosion changes very rapidly. It decreases to about 1/10th after a further six hours, to 1/100th after 2 days (7 x 7 hrs) and to 1/1000th after 2 weeks (7 x 7 x 7 hours). This 'seven-tenths rule' enables a quick approximate calculation of the radiation level at any time, on the basis that the intensity of radiation falls by a factor of 10 as the time lengthens by a factor of 7 (in hours).

3.21 Radioactivity of particles being carried by the wind is therefore in the process of decay both before and after they fall to earth. Their radioactivity is significantly reduced from hour-to-hour whilst in the air, and, depending on wind velocity, may not be of great concern when deposited hundreds of kilometres away from ground zero.

Long Term Effects of Nuclear Weapons Explosions

3.22 Radioactive Fallout. Most of the radioactive debris from nuclear weapons explosions falls out in the same hemisphere in which the explosions occur. Consequently, the fallout from a nuclear war in which nearly all the explosions take place in the Northern Hemisphere should be deposited in that hemisphere at first. For ground bursts, and some water bursts, when the weapon has a high yield, a considerable amount of the material resulting from the explosion will penetrate the troposphere and remain there for many years, and very little would reach the Southern Hemisphere. As the air movements of the stratosphere and troposphere are separate circulations, a proportion of the material will subsequently cross the equator through mixing of the stratospheric air between the hemispheres. The material will gradually fall to earth over many years, but the dose from that fallout will be small compared to other radiation doses to which populations are exposed.

Nuclear Winter

3.23 Possible long-term climatic and ecological effects of global nuclear war have been assessed in some detail for the Northern Hemisphere, and to a lesser extent for the Southern Hemisphere.

3.24 Scientists from the Commonwealth Scientific and Industrial Research Organisation's (CSIRO) Division of Atmospheric Research have played an important part in a major international study on the environmental consequences of nuclear war, written for the Scientific Committee on Problems of the Environment (SCOPE). Volume 1 of the SCOPE report, 'Physical and Atmospheric Effects', pays significant attention to possible effects in the Southern Hemisphere of a war fought essentially in the Northern Hemisphere.

3.25 The report states that effects on the Southern Hemisphere would occur due to solar heating of smoke injected into the Northern Hemisphere in the northern spring and summer months. The smoke would be carried upwards and towards the equator, strengthening the normal high altitude air flow into the Southern Hemisphere. Within one or two weeks, thin, extended smoke layers could appear in mid-latitudes of the Southern Hemisphere, as a precursor to the development of a more uniform veil of smoke capable of reducing sunlight at the surface by some tens of percent.

3.26 At present the precise climatic consequences of this smoke veil over the Southern Hemisphere are not known. It would depend on the lifetime of the smoke in the upper atmosphere and on the degree to which stored heat in the vast oceans of the Southern Hemisphere would moderate the cooling to be expected over land. The climatic disruption could be of a magnitude unprecedented since the last ice age, but probably far less severe than in the Northern Hemisphere.

3.27 In Volume 2 of the SCOPE report a study is made of a 'worst case scenario' in which no crops are grown globally for a full year following a major nuclear war. This could be realistic for the tropics and the Northern Hemisphere, but may well be an exaggeration for the Southern Hemisphere. Assuming that stored food survives in proportion to the surviving population due to the direct effects, and that no food is wasted on people who would not survive a full year, the authors calculated how many people would survive. They found that mass starvation would kill several thousand million people, including most of the population of the tropics and northern sub-tropics outside the combatant countries. This is roughly ten times the estimated number of direct casualties from the nuclear explosions.

3.28 It is important, however, to note that, unless Australia were to be directly attacked, it would have the greatest survival rates, with little mass starvation. This is because we normally have large food surpluses for export, and would be amongst the least affected by climatic disruption.

3.29 Research is continuing in CSIRO Division of Atmospheric Research on transport of soot into the Southern Hemisphere and its possible climatic effects.

PART 4

RADIATION EFFECTS ON HUMANS

4.1 Human beings have always been exposed to radiation from natural sources, and this is referred to as natural background radiation. It is received in the form of cosmic radiation from outer space, from naturally occuring radioactivity in soil, rocks etc (called terrestrial radiation) and from radioactive material within our own bodies. Radioactivity is also present to differing degrees in building materials, the food we eat and the air we breath. The amount of radiation received from all these sources is small.

4.2 Radiation is also received by individuals at other times and it is useful to compare these radiation levels with those from natural background radiation. For example, whilst there is a considerable range in the doses delivered to patients undergoing X-ray diagnostic examination, the average annual doses received by Australians from the examinations is less than one quarter of the dose from natural background radiation. Similarly, the average doses received each year by radiation workers is about one quarter of that from natural background radiation.

4.3 Very much larger doses are necessary before any symptoms of radiation sickness appear. Symptoms do not appear until some time after exposure to radiation, the time depending on the dose received. If the dose is very high, the first symptoms, nausea and shock, would come within a few hours. These would be followed, in the first day or two, by vomiting, diarrhoea and fever, accompanied by tiredness and depression, but little pain. Other symptoms are loss of appetite, loss of hair (which grows again as the individual recovers), internal bleeding and bleeding of the mouth and gums. Where the doses are high but not sufficient to cause very early effects, symptoms of radiation sickness could appear after several days, or even 2-3 weeks.

4.4 People with radiation sickness have less than normal resistance to infection, so that careful medical attention would have to be given to even the simplest cuts or wounds. The mouth and gums would need to be kept scrupulously clean. Affected people should, if possible, be kept warm and be allowed complete physical and mental rest.

4.5 A healthy body has an ability to fight the ill-effects caused by radiation, just as it has an ability to fight normal sickness. Given time, and with the help of modern medicines, the body can return to a state of good health, provided that the dose received was not excessive.

4.6 Special instruments or equipment may be used to measure the radiation levels within humans, in the air and on the ground. The unit of measurement used in Australia since the advent of metrication, is the millisievert (abbreviated to mSv). Prior

to metrication, the unit of measurement was the roentgen (R). For readers who are familiar with R rather than mSv, the approximate conversion is 1R = 10 mSv.

4.7 The radiation dose that causes death varies from one person to another. Research shows that a dose of less than 1500 mSv within one week would not cause death nor any appreciable sickness. But damage to the human body and the degree of sickness rapidly increases above this amount until a person who has received in excess of 5000 mSv over a short period (within one week) has a 50 percent chance or less of survival. For example, such a dose would be received by an exposed person, if unprotected from immediate radiation, at a distance of 1 1/4 kilometres from a 20 kt explosion, and at a distance of 3 1/2 kilometres from a 10 Mt explosion. The dose rate becomes rapidly smaller beyond these distances.

4.8 However, persons who are confined to inadequate or expedient shelter after a nuclear attack would be under stress and possibly without medicines to fight infections. They may also lack adequate food and water. Under these adverse conditions recovery chances would be reduced and the 50 per cent lethal dose would be below 5000 mSv. A lethal dose of whole-body gamma radiation is normally considered to be one exceeding 6000 mSv, received over a short period (within one week).

4.9 There is, however, an effect of exposure to radiation further to those described in the preceding paragraphs. This is the appearance at much later times of a small increase in the rate of incidence of certain forms of cancer in a population exposed to radiation. An exposure of one million people to the equivalent of 10 years of natural background radiation - the level of exposure experienced 2 km away from a 20 kt explosion - might cause about 200 future cases of fatal cancer in that population. It should be noted that the average deathrate from cancer in a population of one million is about 1,600 in any one year.

4.10 Current world nuclear weapons stocks are estimated at about 20,000 megatonnes. Nuclear weapons tested in the atmosphere have been predominantly in the Northern Hemisphere and have yielded a total of about 500 megatonnes. These have resulted in a 'dose commitment' in Australia of about 1mSv, which is about one half of one year's dose from naturally occurring radiation. If all existing nuclear weapons were to be exploded in a similar geographical location, Australia's dose commitment of about 40 mSv would be below the annual limit of 50 mSv recommended for radiation workers.

4.11 Evidence from scientific findings to-date does not support the fears of radiation damage to future generations. The evidence of Hiroshima and Nagasaki shows that the incidence of abnormalities among children conceived by parents who were exposed to the radiation is no greater than that among children born to unexposed parents. However, this does not mean that there would be no genetic damage to children of future generations, or that some unborn children would not be damaged by

large radiation doses. Genetic defects occur naturally in live births, to the extent of several percent of live births; any gross damage in the embryo is lost to future generations through miscarriages and stillbirths.

4.12 It should also be mentioned that people exposed to fallout radiation do not become 'radioactive'. Radiation sickness is not contagious or infectious to others; a person cannot 'catch it' from another person.

PART 5

PROTECTIVE MEASURES AGAINST THE EFFECTS OF NUCLEAR WEAPONS EXPLOSIONS

General

5.1 If a nuclear weapon were detonated in or near a city, either as an air burst or ground burst, large scale destruction of life and property could be expected, followed by severe disruption to normal living patterns. The situation would be made a great deal worse by more than one explosion. Total loss of life could be expected to occur in the immediate vicinity of ground zero, for example, in the vicinity of the crater in the case of a ground burst.

5.2 Yet even if the destruction of property within a city is almost total, this does not mean that there would be total loss of life, or that all humanity would perish in the event of so-called global nuclear warfare. Organising protection against the event of a nuclear attack is not a futile exercise and lives can be saved by sensible planning.

5.3 Although damage to property and loss of life at Nagasaki was very extensive, many people who were underground at the time survived and are alive today. Many 'backyard' shelters, below ground level and simply constructed of timber and earth for protection against conventional bombs, remained undamaged (FIG 6). It is pertinent to note that in Hiroshima and Nagasaki, 229,000 people - more than half the 430,000 within about 5 kilometres of ground zero - were uninjured.

FIG 6

Undamaged earth-covered family shelter in Nagasaki.

5.4 It is not possible to predict what warning of nuclear attack might occur. A range of warning indicators from growing tension between the super-powers to large-scale troop movements and conventional war could alert people and governments.

5.5 Our aim should be to use to the maximum advantage whatever warning may occur. Measures could include dispersal, preparation of shelters and storage of food, water, and other necessities for survival. This booklet is part of the process of informing people of steps that can be taken in advance. Commonwealth and State Governments would at the time provide, through radio, television, and newspapers, particular guidance on the most appropriate protective measures to take in the circumstances.

Shielding From the Effects of Nuclear Explosions

5.6 Some nuclear shelters are constructed primarily for protection against the dangers of radioactive fallout. The dangers of heat and blast are often ignored. Thus, an above ground shelter at the fringe of a possible target area, built to keep out fallout but structurally weak against blast, may be considered a risk in that particular location, but not a risk at some remote area, say on a farm 50 kilometres distant from the target area.

5.7 As a general rule, shelters should be built to protect against heat, blast and fallout. The best shelters affording protection against these effects would be those below ground level, because dangerous blast and heat waves could pass overhead, and earth significantly attenuates blast waves.

5.8 Some gamma radiation from fallout could penetrate the shielding materials of good quality shelters, but the dose received by the occupants may be no more than that received during a few years of exposure to natural background radiation.

5.9 Design features of shelters must therefore include the use of adequate shielding material. Materials such as earth, concrete and solid bricks are good for shielding. Nine centimetres of packed earth will reduce penetration by gamma rays by approximately 50%; 18 centimetres by approximatley 75%. Figure 7 shows in a simplified way that the number of incident gamma rays is halved after the penetration of each slab of packed earth. On this basis, if additional 9 centimetre slabs of packed earth are successively added to the five slabs shown in Figure 7, the protection factor is successively increased from 32 to 64, to 128, to 256, to 512, and so on.

FIG 7

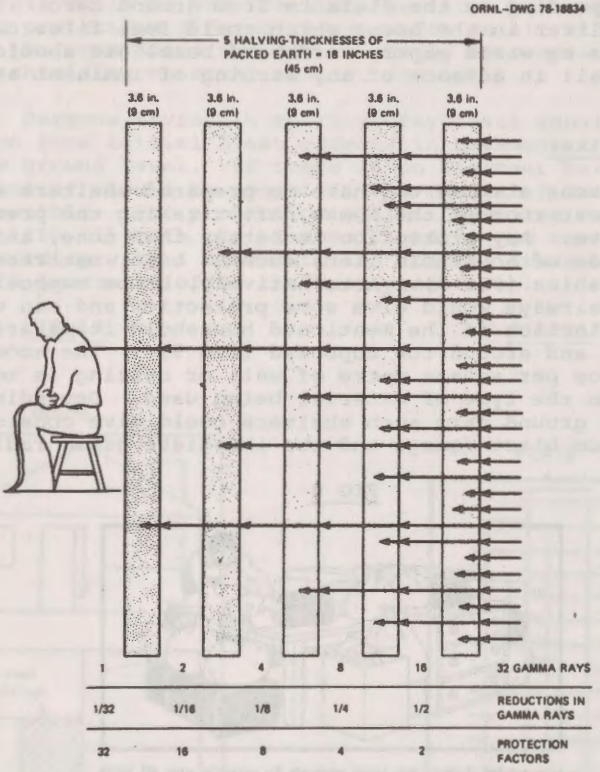


Illustration of shielding against radiation. Note the increasing large improvement attenuation (reduction) factors that are attained at each additional halving-thickness of packed earth.

NOTE: 30cm (12 inches) of concrete or 45cm (18 inches) of solid bricks would provide the same protection as the 45cm of packed earth shown in this figure.

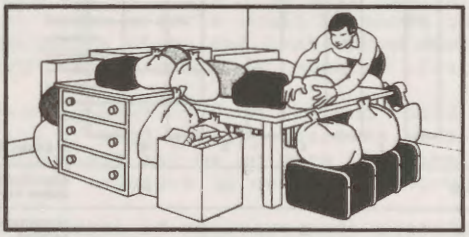
5.10 The length of warning time will undoubtedly affect the state of shelter preparedness of many people and families. Little warning time, say less than a day, would mean in many instances hasty preparation of shelters. Preparations taken over weeks or months would allow for the building of shelters that provide greater protection and comfort.

5.11 If warning of an attack is received persons at home or at work should firstly ensure that supplies such as water, gas and electricity are turned off, open fires are put out, and that windows are shut and curtains drawn. They should then go to their shelters. Dangerous fallout from a ground burst would begin to reach the ground about 30 minutes onwards after an explosion, depending on the distance from ground zero. Unnecessary litter in the house which could fuel fires caused by the heat waves eg waste paper, cardboard boxes etc should be disposed of well in advance of any warning of imminent attack.

Expedient Shelter

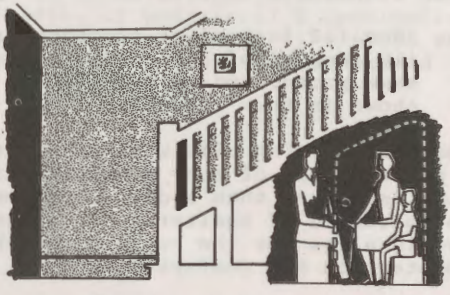
5.12 Persons at home who have no prepared shelters should go to the innermost room of the house, after taking the precautions mentioned above. Any protection is better than none, and good use can be made of household items such as beds, mattresses, couches and tables (FIG 8). Alternatively, broom cupboards underneath stairways would give some protection and can offer increased protection if the mentioned household items are piled on the stairs and around the cupboard (FIG 9) . The amount of weight in kilos per square metre of wall or ceiling is more important than the type of material being used. Depending on the distance from ground zero such shelters could give considerable protection from blast damage and the immediate gamma radiation.

FIG 8



Use tables if they are large enough to provide you all with shelter. Surround them and cover them with heavy furniture, bags filled with sand, earth, books or clothing.

FIG 9



The stairs would give some protection against falling debris.

5.13 If utilising an inner room of the house (FIG 1Ø), this should, ideally, be thickly lined on all sides, as well as the ceiling area above the room. Dense and thick materials provide better protection from fallout.

5.14 If your house has a below-ground level room such as a cellar, this would be the ideal shelter area because of the excellent protection offered by the earth on all sides. The floor of the room above the cellar should be overlaid with adequate shielding material against fallout.

5.15 Persons living in multi-storey flats should seek protection from initial blast effects in basement areas if these are below ground level. If there is no basement below ground level, shelter should be sought in the centre of the building, as low as possible. For protection against ionising radiation from fallout, (FIG 11) both the basement, and in the case of a 1Ø-storey building with a basement, the central areas of storeys, 3 to 7 would generally offer the best protection.

FIG 1Ø

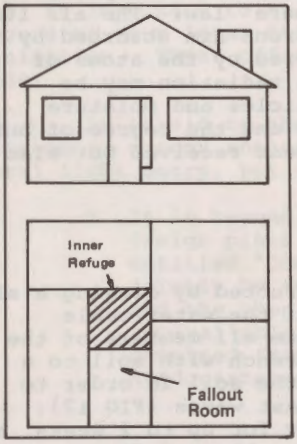
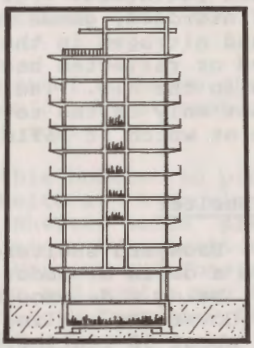


FIG 11



5.16 Caravans offer very little protection from the effects of nuclear weapons explosions. Persons living in caravans should vacate them and seek shelter elsewhere.

5.17 Persons caught in the open and who cannot get home within minutes, should go immediately to the nearest building. If a building is not nearby, use any kind of cover that might be available for protection against light flash, heat and blast eg ditches or culverts. After the passing of these dangers, proceed quickly to any structure that would offer protection against fallout.

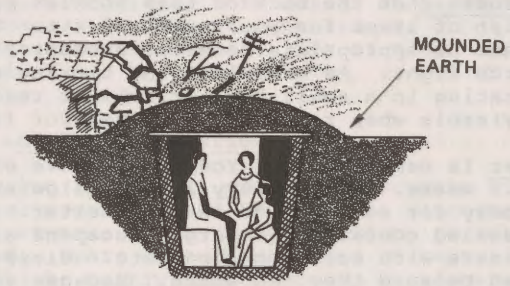
5.18 The intensity of radiation received by a person exposed to a single source such as the fireball of a nuclear weapon decreases rapidly with distance from that source. If the distance is doubled the intensity falls to a quarter of its previous strength and if the distance is trebled it falls to a ninth (1/3 x 1/3). In other words, it decreases by a factor which is proportional to the square of the distance from the source. This 'inverse square' law applies to all forms of radiation, including light and heat. Each radioactive fallout particle can also be regarded as a source. This is one of the reasons why it is desirable to shelter in the basement or in an inner room of a house to get as far away as possible from sources of penetrating gamma radiation such as fallout on the roof and around outside walls.

5.19 In practice, other factors make the amount of heat or gamma radiation received by a person decrease more rapidly than would be predicted from the 'inverse square' law. The air itself attenuates radiation. For example, neutrons are absorbed by the atoms of nitrogen, gamma rays are scattered by the atoms of oxygen and nitrogen in the air, and heat radiation may be scattered or reflected back by dust particles and moisture droplets in the air. The extent of fire and the degree of burns depend not only on the total amount of heat received but also on the rate at which it falls on a surface.

Planned Shelter

5.20 Backyard shelters can be constructed by digging a slit trench to a depth of about two metres (if the water-table permits), being wide enough to accommodate all members of the family. Cover the ceiling of the slit trench with soil to a depth of about 50 centimetres. 'Mound' the soil in order to reduce the possibility of movement by blast waves (FIG 12). Because you may have to stay in a shelter for up to 2 weeks, make it as comfortable as possible. Line the walls and floor. Have chairs and adequate bedding. Part 6 of this booklet will outline the essential items that should, ideally, be taken to the shelter. Where soils are light - say, very sandy soils - it is important to reinforce the walls of the trench to avoid the possibility of the soil crumbling.

FIG 12



A slit trench with earth covering protects against heat, blast, immediate radiation and radioactive fallout

5.21 Should a person prefer to build his backyard shelter above the ground, make good use of ground contours. For example, if the ground is steeply sloping, a little digging can have one (or more) side of the shelter braced against the bank.

5.22 However simple or elaborate you desire the shelter to be, it is important to talk about your plans with appropriate officers of your local State or Territory Emergency Service organisation. These officers are competent to offer good advice.

5.23 As an aid to the overall comfort of an above ground or partly-above ground shelter, design* should take account of some natural light entry, but via an indirect route.

* It is beyond the scope of this booklet to provide design plans for fallout shelters. A booklet, entitled 'Domestic Fallout Shelter Guide' prepared jointly by the Natural Disasters Organisation (NDO) and the then Department of Housing and Construction, is available on this subject and copies may be obtained from State or Territory Emergency Service headquarters or from the NDO.

PART 6 - SHELTER SURVIVAL KIT

6.1 Appendix 2 at the back of this booklet provides a visual checklist of items for your survival kit. Some items listed might not be appropriate to small shelters, or to shelters relying on torch light. As examples, the ticking of a clock could be irritating in a small shelter, whilst reading or writing would be inadvisable when relying on torches for lighting.

6.2 Water is essential. You should have enough water to last at least 2 weeks. At the very least, allow about 14 litres for drinking only for each person in the shelter. The water should be in sealed containers - large saucepans with lids, plastic containers with screw-on caps, etc. Glass bottles are not recommended because they can smash. Because you will be coping 'in the dark', probably by torchlight, avoid using glassware.

6.3 It would be wise to stock much more water than 14 litres per person because the blast and fallout may have destroyed or contaminated the normal water supply. You would then have some water for basic hygiene in the shelter, and to drink when you emerge from the shelter. Remember, boiling cannot remove radioactivity from water, although some filtering techniques can be successful eg. by filtering through a considerable depth of clean sand or through clayey loam.

6.4 Canned drinks such as fruit juices or soft drinks are recommended. But if drinking from the actual can, make sure you dust it - some radioactive dust may have settled on it, although the contents will be unaffected.

6.5 Food. Cooking is not recommended in small shelters. Elaborate shelters may have cooking facilities (eg, a small kerosene stove), however, darkness would make cooking difficult and fumes could make life more uncomfortable.

6.6 Therefore choose foods that can be eaten cold, preferably canned foods. Most canned foods can be eaten cold, such as meats and vegetables and the range of baby foods.

6.7 Packaged foods of the 'dried' variety are also recommended: dried fruits and nuts, cereals, powdered milk and biscuits.

6.8 If you do bring some perishable foods into the shelter, it is common sense to eat these first. As with water, store the perishable foods in sealed containers.

6.9 During confinement to the shelter, eat sparingly because foods may be in short supply for some weeks after an attack.

6.10 Stocks of canned foods, drinks, and dehydrated foods in a shelter must be periodically checked to see if their 'shelf-life' has not passed. Periodic rotation of foods is therefore most important. Properly processed unopened canned foods can be stored at 21-24 degrees celsius for at least 12 months. Many

canned foods will keep longer but because of uncertainty as to the true age of the food a 12 month maximum should be set. Canned rhubarb, fruit juices, soft drinks and some baby foods are exceptions and have a maximum storage life of about 6 months. Dehydrated foods also have a shelf-life of about 6 months at 21-24 degrees celsius.

Portable Radio and Spare Batteries

6.11 Following an attack, your shelter radio will be your link with people, provided that EMP has not disrupted communications networks. The radio should be portable and battery operated. Spare batteries should be kept in the shelter. It will be mainly through radio broadcasts that you will know the extent of damage, the expected fallout directions and levels, and the time when it will be safe to emerge from the shelter. Replace old batteries with new ones periodically.

First Aid Kit

6.12 Kits should include strong disinfectant, cotton wool, bandages and dressings, aspirin (or similar pain-easers) and scissors. Prescribed medicines such as anti-biotics may be necessary to combat infections and should be obtained if time permits.

6.13 Other Items. Do not forget can-openers, knives, forks, spoons, plates (plastic preferably), drinking mugs, warm clothing, bedding, torches with spare batteries and bulbs, table and chairs, washing bucket, toilet rolls. and non-abrasive soap. Toys for children are a good idea - young children will be confused and under stress. Their favourite toys would be a comfort.

Sanitation

6.14 A polythene or plastic bag placed in a bucket or garbage can (dust bin) can act as a toilet. To overcome unpleasant odours, the bag can be tightly tied after each use and a tight-fitting lid applied.

6.15 When fallout radiation has decayed to a tolerable level and if the toilet and shower facilities in the home are still functioning, these facilities may be used in homes which receive reticulated water. Non-reticulated water supplies (ie tank water used by some farmers or isolated rural communities) may be used for drinking or showering if contamination by fallout radiation has not occurred. Contamination would occur if fallout on the roof of the house was washed into the tank by rain, but in the absence of rain contamination would be minimal because most tanks are closed. Contamination of underground bore water would be unlikely and this water would be safe to drink.

6.16 After showering or using the toilet, return promptly to the shelter so as to minimise exposure to remaining fallout. Wipe toilet seats before use. Take off your shoes and outer clothing before entering the shelter because some fallout might have been picked up by these articles. Leave these articles outside the shelter for use on other occasions when leaving the shelter.

6.17 Even in communities that received heavy accumulations of fallout particles, people may with safety leave their shelters to perform emergency tasks for a few minutes or a few hours at a time providing radiation has decayed to a tolerable level.

PART 7

FOOD SUPPLIES AFTER A NUCLEAR EXPLOSION

7.1 Packaged food in undamaged sealed containers should be satisfactory for consumption after an explosion, but there may be some radioactive contamination on the outside of the package. The package should be cleaned before opening to remove any dust or contamination. Other food may be available for a limited period of time, having been stockpiled in advance in shelters or in stores set aside for the purpose. Fresh food may still be available from an area not directly affected by the explosion, although it may have been in an area where fallout has occurred. Such food can still be used, but proper handling and preparation is necessary to avoid contamination of people handling it and to avoid ingesting radioactive material. The following is set out to assist in knowing how to handle and prepare food.

Fallout Effects on Crops

7.2 Radioactive fallout may contaminate large areas of crops and pastures. Direct contamination is a short-term problem, being at a maximum immediately after fallout begins to settle on the ground, and decreasing with time as the radioactivity decays and the fallout particles are removed by wind and rain. If the crops were consumed without an attempt to remove the adhering radioactive particles, there could be an ingestion hazard. The usual methods of food processing and preparation would eliminate most of the risk, as shown by the following examples:

- Cereals (eg wheat, barley) - Fallout particles lodge mainly in the outer part of the ear. The threshing process and rejection of the husk portion after milling would remove up to 90% of the original contamination.

- Root Crops (eg potatoes, carrots, beet) - The direct contamination hazard to the root is negligible. Rejection of the contaminated tops, and washing (in uncontaminated water) or peeling of the root would give almost complete decontamination.

- Leafy Vegetables (eg lettuce, cabbage) - The rough leaf and open structure of this class of vegetables could result in high retention of fallout particles. Decontamination would be achieved by rejecting the outer leaves and washing the remainder.

- Legumes (eg peas, beans) - The pod structure of peas provides a natural protective cover and pod removal ensures almost complete decontamination. Peeling of beans is necessary.

- Fruits (eg apples, pears) - Washing and peeling would provide almost complete decontamination. However, 'soft' fruits and berries such as plums and blackberries are difficult to peel and should be avoided, although washing would eliminate most of the contamination.

- Tomatoes - If in the open, peeling and washing would eliminate most of the contamination. This is advisable even if they are grown in undamaged greenhouses.

7.3 As a general rule, crops known to be contaminated by radioactive fallout should not be consumed if safer food sources are available.

Fallout Effects on Livestock

7.4 Fallout particles could be retained on the coats of grazing animals and could also be inhaled or ingested from pasture. The animals would then suffer from the combined effects of external and internal beta radiation as well as those of environmental gamma radiation. In the case of cattle and sheep, fallout particles could be trapped and accumulate in the rumen with resultant ulceration. As far as possible, grazing animals would need to be brought under cover from fallout and given uncontaminated fodder and water. In affording protection, priority should be given to breeding stocks. Because few radioactive isotopes (or atoms) accumulate in the flesh, animals that become sick from exposure to radiation, if slaughtered before death occurs from radiation sickness, should provide good clean meat. Care would need to be taken in removing the hide and offal.

Fallout Effects on Eggs, Milk and Fish

7.5 Eggs derived from exposed but surviving animals should not contain enough radioactivity to present a serious ingestion hazard, because of the protection afforded by the shells. Free-range hens would obviously be at greater risk of dying than those kept under cover. Thyroid damage from the consumption of eggs from apparently healthy poultry can be discounted.

7.6 The main ingestion hazard in the immediate post-explosion period is presented by the consumption of milk and milk products, derived from dairy cattle which have grazed contaminated pastures. Owing to the concentration of radioactive iodine in the animal's thyroid and its rapid transfer into the milk, the radioactive level would reach a maximum after about 2 to 3 days. The risk to children would be avoided by the use of milk powder for about 3 weeks, or of milk substitutes or milk from cows kept under cover and fed on uncontaminated fodder. Contaminated milk could be used to prepare products such as cheese or butter, where normal storage prior to consumption would allow progressive decay of the iodine isotopes.

7.7 Radiation effects from fallout on fish in the sea would not be serious. However, fish in the vicinity of an under-sea or near-surface explosion should not be eaten. Shellfish and crustaceans from shallower coastal areas could constitute a risk in the immediate post-explosion stage.

At the same time, two or three other neutrons are released. This fission process is responsible for the large quantities of nuclear energy released in an atomic reactor or in the explosion of a nuclear weapon. The fissile charge even in a small nuclear weapon, although it may weigh only about 2 kilogrammes contains multiple-millions of atoms and these do not all split up in quite the same way. The products of fission contain, therefore, about 200 different radioactive isotopes of about 35 elements.

Critical Sizes of Fissile Charges

11. When a piece of fissile material is below a certain critical size, a few of the atoms are continually undergoing fission, but more neutrons escape from its surface than are produced in fission and prevent the build-up of an increasing chain of fissions. If several pieces of fissile material, totalling more than the critical amount, are suddenly brought together inside a strong container or tamper, a nuclear explosion results. The critical size depends upon a number of factors including whether the material is solid metal or in a porous, spongy form, the nature of the container and whether it absorbs neutrons or can reflect them back into the fissile charge.

12. Published information suggests that an unconfined sphere of U-235 metal of about 16-17 cm diameter and weighing about 48 kilogrammes would be a critical amount: this would be reduced to about 11-12 cm diameter (16kg) for a U-235 sphere enclosed in a heavy tamper. The critical mass of unconfined Pu-239 is about 10kg, but in an efficiently designed weapon can be reduced to about 2kg. The increasing mechanical complication of bringing together, rapidly and simultaneously, a number of sub-critical pieces of fissile material sets a practical limit to the power of nuclear fission weapons.

Nuclear Fission and Thermonuclear Weapons

13. A temperature of several million degrees celsius is reached in the explosion of a nuclear fission weapon. At this temperature atoms are stripped of most of their surrounding cloud of electrons and the nuclei move at very high speeds, experiencing many collisions with one another. In these circumstances, the nuclei of the rarer hydrogen isotopes deuterium and tritium have enough energy of motion to overcome the repulsive forces between their single positive electrical charges and they are able to fuse together. The energy released in the fusion of these two nuclei is about one-twelfth of that released in the fission of a single U-235 nucleus, but on an equal weight basis, the fusion energy is about two and a half times as large as the energy of fission of U-235.

14. In the process of fusion a neutron is released at a very high speed from each pair of reacting nuclei and it has enough energy to cause fission of the atoms of U-238. Thus, if U-238 is used as the bomb case in a thermonuclear weapon the

quantity of fission products will be increased many times (see paragraph 1.6, Chapter 1). This type of weapon is the fission-fusion-fission type or so-called 'dirty' bomb.

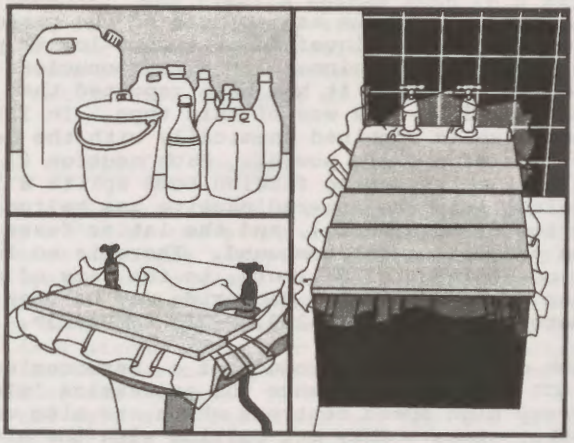
15. Deuterium and tritium as isotopes of the gaseous element hydrogen have to be liquefied at a very low temperature and maintained there for containment in a thermonuclear weapon. This is inconvenient although it has been reported that the first American H-bomb tested in 1952 was of this type. In later weapons the deuterium is combined chemically with the metal lithium in the form of a white powder. Each neutron (1 mass unit) released by the triggering fission bomb splits a lithium atom (6 mass units) into the non-radioactive gas helium (4 mass units) and tritium (3 mass units), and the latter fuses with the deuterium atoms present in the compound. There is no limit, other than the convenience of delivery, to the size of a fusion or thermonuclear weapon. Lithium deuteride may be less costly than fissile materials such as U-233, U-235 or Pu-239.

16. Helium gas, the main product of a thermonuclear explosion, is NOT radioactive (hence the expression 'clean' bomb) but the very high speed neutrons which are also emitted collide with other atoms. They may collide with the nitrogen atoms in the atmosphere and release a very intense and penetrating form of gamma radiation (flash). They may induce intense radioactivity in some of the ground material if the weapon is burst on the ground - but this decays rapidly in a few days, except for a small number of components which decay slowly.

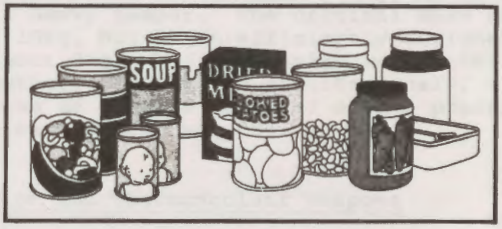
APPENDIX 2

SHELTER SURVIVAL KIT CHECKLIST

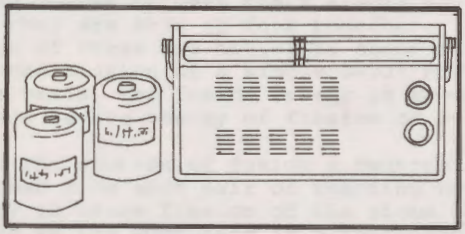
1. Water



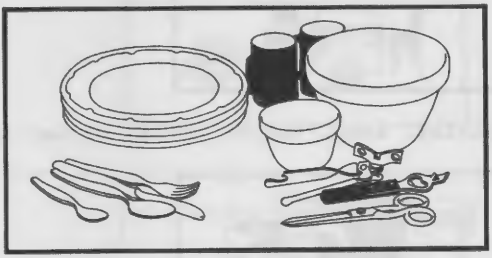
2. Food



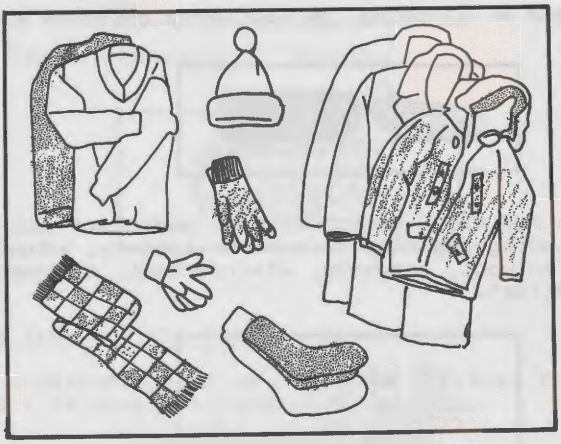
3. Portable Radio and Spare Batteries



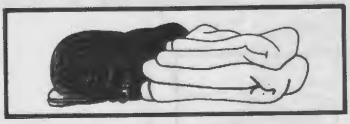
4. Tin Opener, Bottle Opener, Cutlery, Plastic Plates and Mugs



5. Warm Clothing

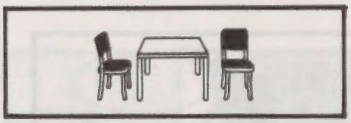


6. Bedding, sleeping bags



7. Torches with spare bulbs and batteries, candles, matches

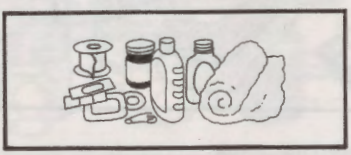
8. Table and chairs



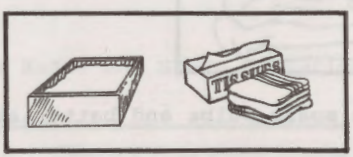
9. Toilet articles, soap, toilet rolls, bucket and plastic bags

1Ø. Changes of clothing, particularly children's underwear

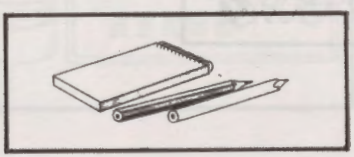
11. First Aid Kit - with household medicines and prescribed medicines, including aspirins or similar tablets, adhesive dressings, cotton wool, bandages, disinfectant, ointment, including 'Vaseline'.



12. Box of dry sand, cloths or tissues for wiping plates and utensils.

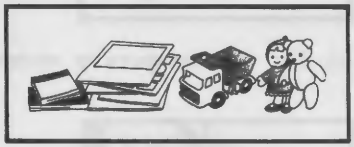


13. Notebook and pencils for messages.

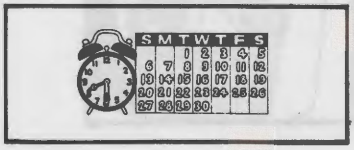


14. Brushes, shovels and cleaning materials, rubber or plastic gloves, dustpan and brush.

15. Toys and magazines.



16. Clock (mechanical), Calendar.

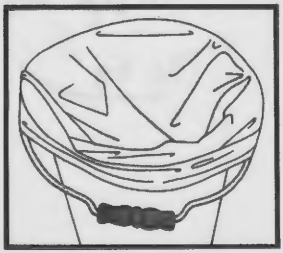


Sanitation

Keep these Items in the Fallout Room:

17. Containers such as polythene buckets, fitted with covers and - if possible - improvised seats.

18. Polythene bag linings for emptying the containers.



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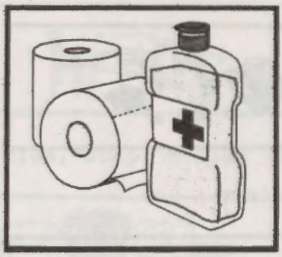
19. Strong disinfectant and toilet paper.



20. A garbage can for the temporary storage of sealed bags of waste matter.

21. A second garbage can for food remains, empty tins and other rubbish.

If you have only one garbage can, use that for toilet waste only. Put all other rubbish in plastic bags or paper until you can take it outside the shelter.

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